Space Weather Technical Forecast

Issued on Thursday, 20 January 2022 at 00:52 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Slight chance G1/Minor Storm intervals from CME arrivals. Active high energy electron fluence.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Very Low with no notable flare activity from the five sunspot regions on the visible disc. AR2929 Dsi/Beta and AR2930 Dso/Beta-gamma are both small bipolar regions showing some sign of decay. AR2927 Axx/Alpha and AR2933 Cao/Beta are also exhibiting slight decay, with leader spot of the showing signs of breaking up. A new Hsx/alpha region has also recently rotated onto the southwest disc. An Earth-directed CME was observed on STEREO A coronagraph, and very faintly on SOHO LASCO imagery due to a filament lift from the southwest disc around 19/0200 UTC.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR and ACE at L1 was dominated by the passing of a CME, which likely originated from a near central disc filament eruption on the 15th, alongside the declining fast wind of CH44, Wind speeds were strong, peaking 680 km/s at 19/0627 UTC before declining to be elevated at around 550 km/s. Density was variable, but peaked 16ppcc at around 19/0910 UTC, and also showed a marked drop off at 19/2110UTC. The total interplanetary magnetic field strength (IMF), Bt, was moderate 8-10nT at first, but declined to be below 6nT from 19/0730 UTC. The north-south component peaked -8nT at 19/0130 UTC, before rapidly rotating to peak +8nT at 19/0300 UTC. Further rotations in the field occurred but with decreasing strength until around 19/1200 UTC, after which the field became weak. Phi angle was variable until 1200 UTC, when it became slightly positively pointed (away from the Sun). G2/Moderate Storm interval were observed 19/0000-0300 UTC, with G1/Minor storm 0300-0600 UTC. Geomagnetic activity was then Quiet to Unsettled (Kp 2-3)

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) measured at GOES 16 remained at Background levels throughout. High energy electron flux (greater than 2MeV) measured at GOES 16 was at Moderate to High levels, with a peak value of 3170 pfu at 19/1645 UTC. Electron fluence persisted above the 1e8 Active threshold with 20/0000 UTC observation value of 1.22e8 integrated pfu recorded.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low to Very Low with only a slight chance of M-flares. This risk receding later in the period as AR2929 and AR2930 rotate over the western horizon and off the visible disc on day 2 (21st).

Solar Wind / Geomagnetic Activity: There are three potential CME arrivals through the period. There is a slight chance of a glancing impact early day 1 (20th) from a CME from the C2 flare on the 16th, and a glancing impact is also possible either late day 2 (21st) or early day 3 (22nd) from the CME from the M-flare on the 19th. Both of these are low confidence with the bulk of the CME material missing, passing ahead and to the north of Earth. A further slower, and weak CME on the 19th has the potential to arrive day 4 (23rd), but confidence is low on impacts due to the slow CME speed along with background solar winds being forecast to gradually decline to ambient levels by this stage. Geomagnetic activity is forecast to be mostly Quiet to Unsettled with isolated Active intervals possible, but a slight chance of increasing Active to G1/Minor storm

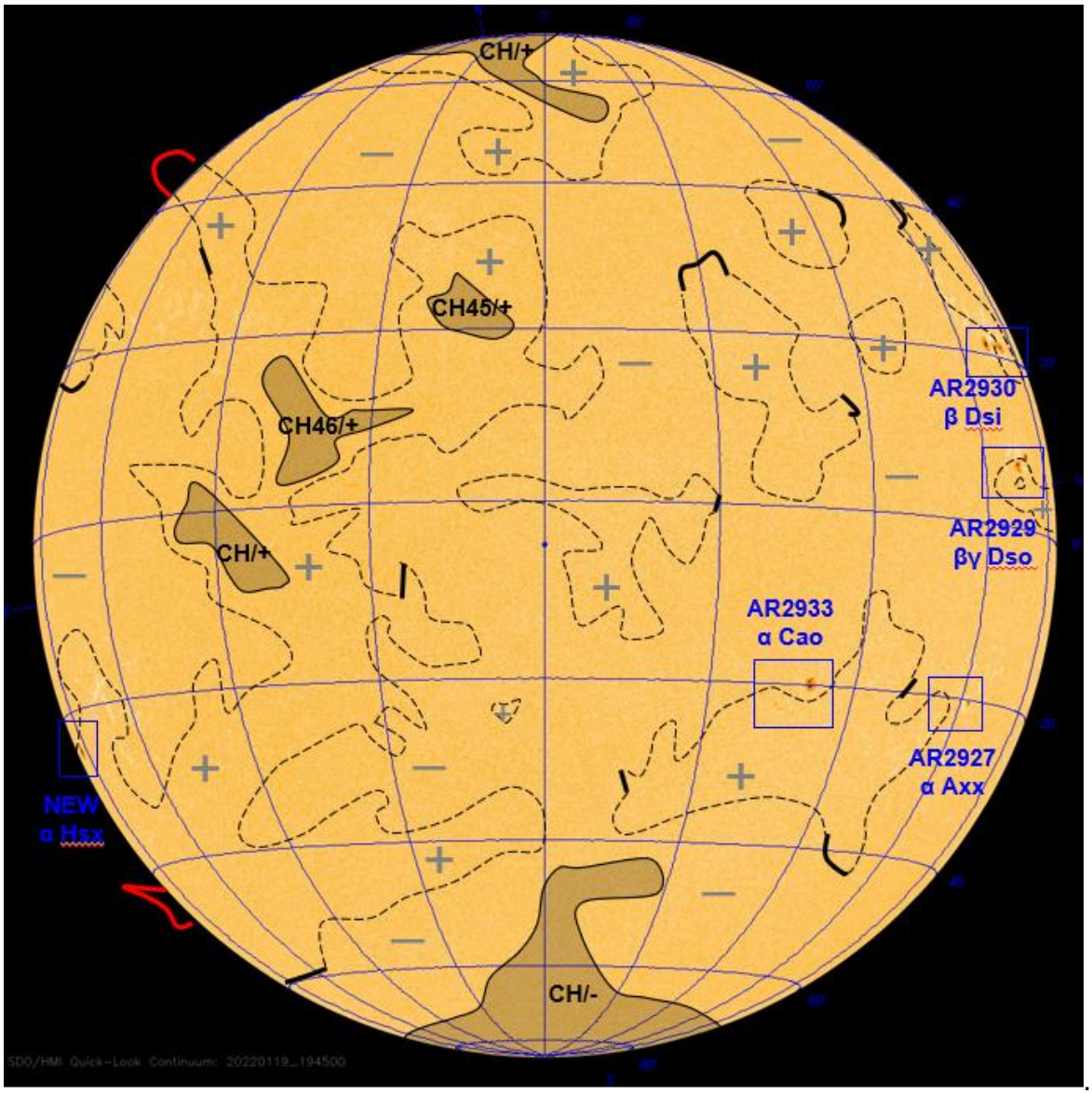
Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

levels from any CME arrival.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is forecast to remain at Background levels. The high energy electron flux (greater than 2MeV) is expected to be continue to at mainly High flux levels through the period , but any CME arrival is likely to bring a noticeable dropout with mainly Moderate, perhaps peak high flux levels following. The 24-hour fluence is forecast to persist above the Active threshold, but with an increasing chance of dropping below this level through the period.

Figure 1. Solar Analysis Valid 19/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Geomagnetic Storms:

There are a number of CMEs that have left the Sun in the last few days which may have Earth-directed components.

A long duration C2 flare on the 16th resulted in a CME which whilst predominately directed north and ahead of Earth, has the potential for a glancing impact early on day 1 (20th). With solar winds currently elevated from the recent fast wind enhancements, and the CME arrival on late on the 18th, any further interaction has the potential to bring G1-Minor Storm conditions for a time. Otherwise solar winds are expected to continue gradually declining

A second CME has the potential to give a glancing impact either late day 2 or early day 3 (21st or 22nd). This is from the M1.5 flare of AR2929, and whilst again the bulk of the CME is directed north and ahead of Earth in its orbit, a glancing interaction is possible. This again bringing a slight chance of G1/Minor Storm intervals.

A third Earth-directed CME was observed primarily on STEREO A but also very faintly on SOHO LASCO on the 19th. This is from a large filament that weakly lifted around 19/0200 UTC. Unlike the previous CMEs, this is a less energetic lift, but from a more conducive location for moving across Earth. Due to its weaker nature, confidence is lower on potential impacts, however, with increased confidence for this to move across Earth, a slight chance of G1/Minor Storm intervals is maintained for day 4 (23rd).

Otherwise winds are expected to gradually ease a background through the period, although a small northward extension of the southern polar coronal hole brings a slight chance of further slightly elevated solar winds day 3 onward (22nd). Geomagnetic activity is forecast to be Quiet to Unsettled with a decreasing chance of Active intervals throughout. But with a slight chance of increasing to Active to G1 Minor Storm on any day, due to the potential CME arrivals.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	20	10	20	20
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

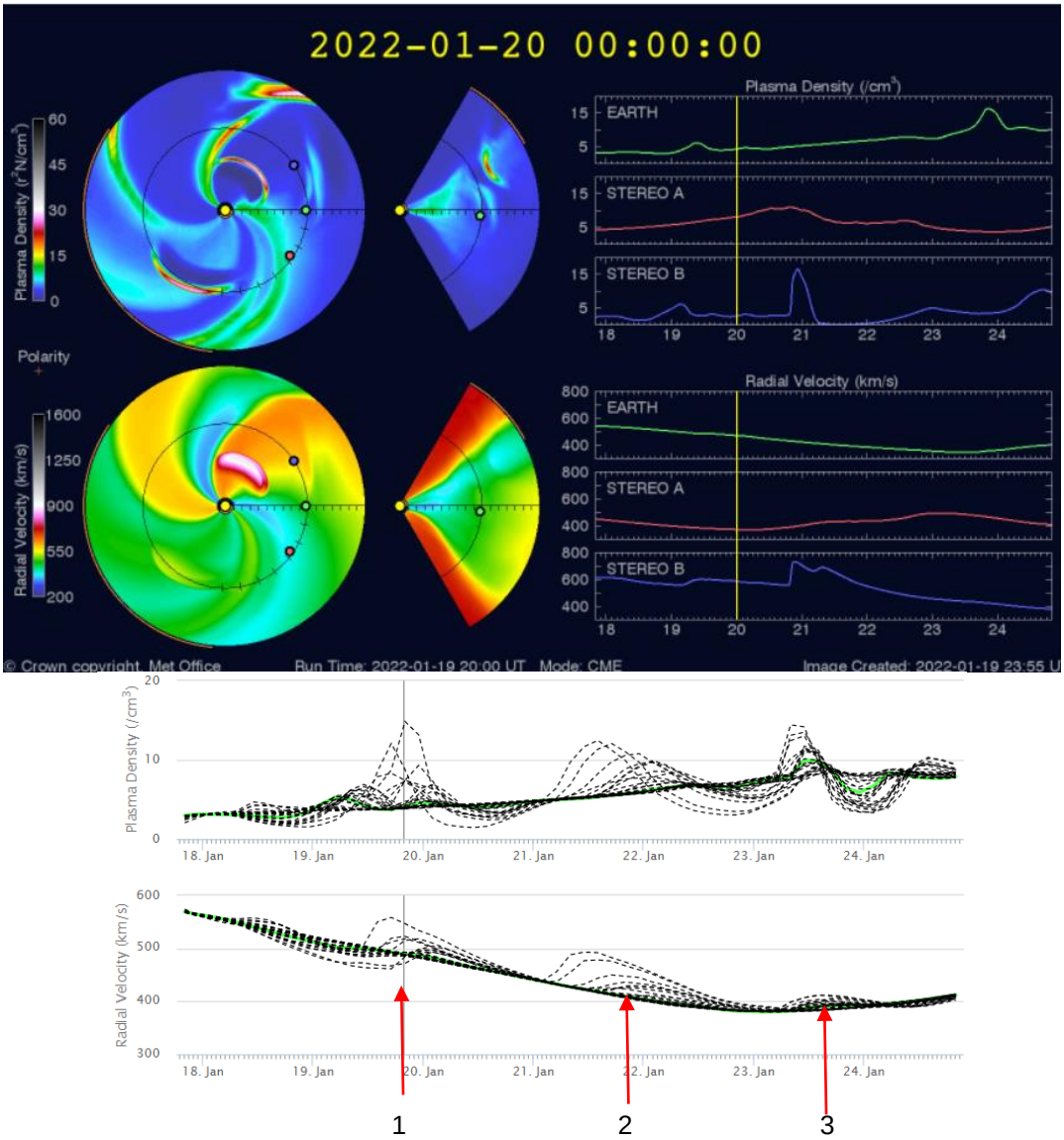
Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
17/01 0235	Partial	C2 flare	24W10N	562	20/0200	Likely missing – but chance of glance (20%)
18/01 2140	Partial	M1.5 flare of AR2929	58W11N	950	22/0000	Bulk missing – only weak sideswipe expected
19/01 1837	Partial	Filament	17W16S	288	23/1500	Low confidence with fit, as very weak on SOHO

Figure 2: Enlil, including ensemble below, showing possible, low chance CME arrivals



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Radio Blackouts - X-Ray Flares:

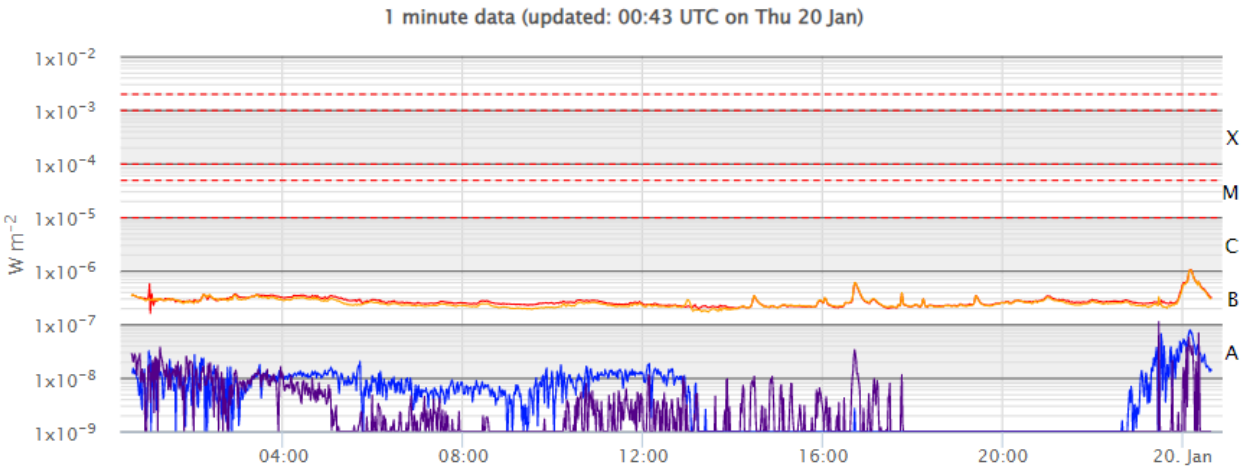
There are five sunspot containing active regions on the Earth-facing disc, and a number of other plage or old active regions. Despite this solar activity has been Very Low in the last 24 hours, with X-ray flux at around B1-B2 and only small B-flares observed.

AR2929 Dsi/Beta and AR2930 Dso/Beta-gamma are both small bipolar regions which are showing some sign of decline, although they are becoming increasingly hard to assess as they approach the western limb. AR2927 Axx/Alpha and AR2933 Cao/Beta are also exhibiting slight decay, with the former now a simple unipolar region and latter showing recent breakup of its leader spot. A new Hsx/alpha region has also recently rotated onto the southwest disc, but will potentially need further analysis as it rotates into a clearer view.

With only small sunspots on the disc activity is expected to persist at Very Low to Low levels, with a slight chance of rising to Moderate from any M-flares that occur. In the absence of any further sunspot development the M-flare risk will recede as AR2929 and AR2930 rotate over the western horizon.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	20	20	10	5
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 3: GOES-16/17 X-ray Flux



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is expected to persist at background levels through the next four days.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	1	1	1	1
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux, as measured by GOES-16 at GEO, is currently High after recent fast wind and CME enhancements. In the absence of any CME arrivals, these high levels would be expected to persist for much of the period, with just a gradual declining trend. However there is a chance that any CME that does glance across the Earth will bring a noticeable dropout, with levels falling to background and perhaps only recovering to Moderate with peak High levels. There are three potential such CME arrivals, early day 1 (20th) around midnight day 2 (21st) into day 3 (22nd) and again day 4 (23rd). The first two of these are low confidence, but the third is anticipated but expected to be weaker. Despite this, a drop out in flux is likely by day 4 (23rd), with a chance of occurring before that.

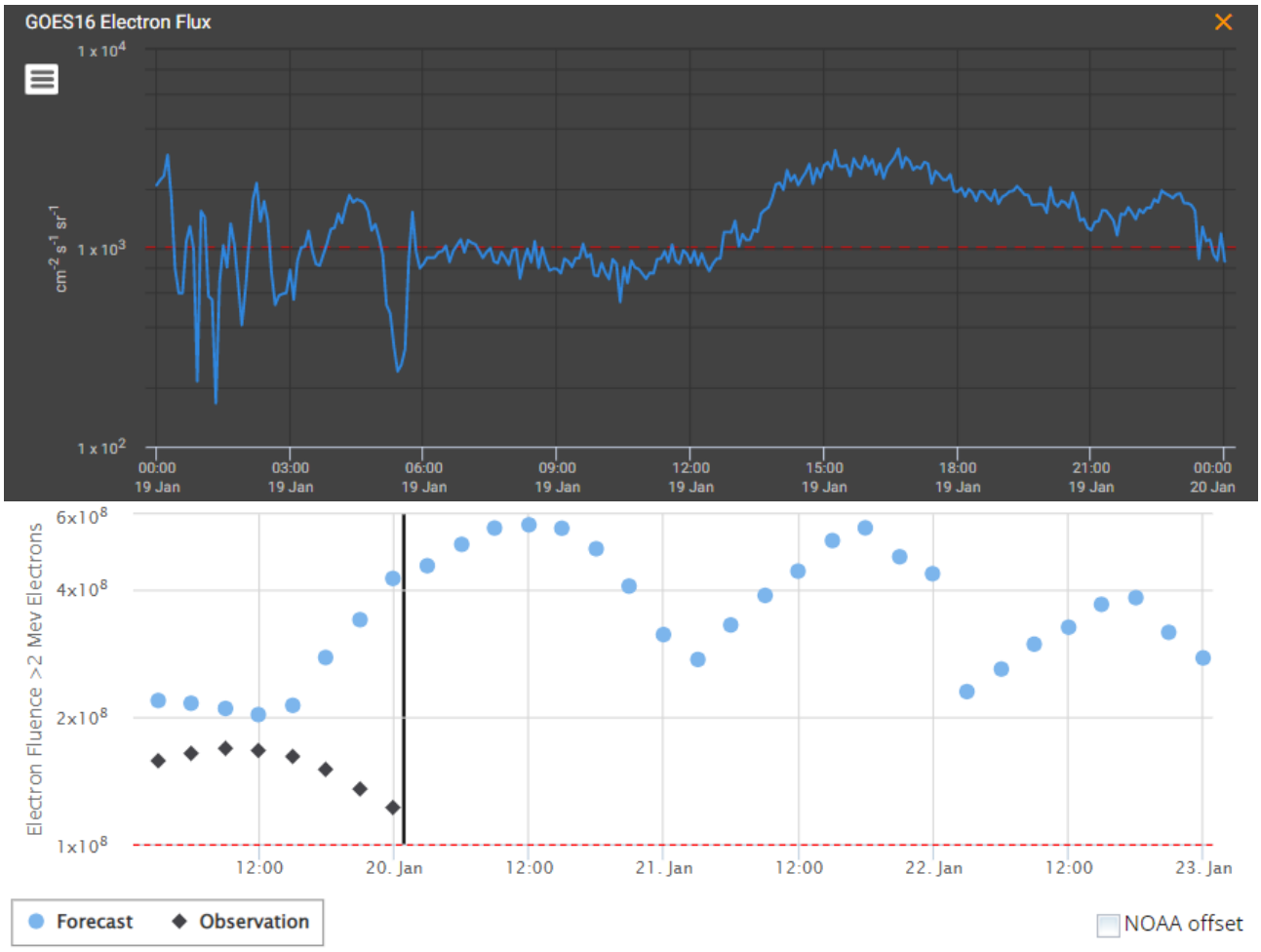
The associated fluence is currently Active (above 1e8 integrated pfu) and expected to persist at this level, but with an increasing chance of falling below due to any flux drop out that occurs, and likely falling below later day 4 (23rd) with the arrival of the third CME. This persistent high flux is supported by REFM, although absolute values indicated by the model are considered too high.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	100	80	60	50
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Figure 4: >2MeV Electron Flux and associated Fluence with REFM



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.